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A monolithic Thermal Inkjet Printhead Combining Anisotropic Etching and Electro Plating

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ABSTRACT

The paper proposed a high resolution single-chip monolithic inkjet printhead by combination glowing of nozzle plate on the silicon substrate and anisotropic etching[1]. Ink channels are defined by a sacrificed layer and etched through a mesh network by anisotropic etching. Silicon based channels are strong enough to against the attack of ink solution. Surface planarzation is achieved by using PECVD deposited low stress dielectric film on top of the channels to seal mesh cavities. The heater elements are buried in a thin-sandwiched membrane and face down like a back shooter[2]. Ink slot is formed by Etching the substrate from the backside and channel is then connected with Ink slot. Electrical forming nozzle plate will be done later. In this structure, no more another ink channel material is necessary since it is formed on Si substrate. By direct forming nozzle plate on chip, alignment for bonding nozzle plate and chip could be avoided to cost down.

Keywords: Monolithic , Anisotropic Etching , Electro plating, Planarization

1. INTRODUCTION

Most of the user requirements for printing system is low cost, variable color, high quality, high speed, high resolution, low cost and excellent software support. The Drop-On-Demand (DOD) type printer has several types according to it's ink ejecting mechanism, that is piezoelectric and thermal type. The piezoelectric type ejects an ink droplet by vibration piezoelectric material while thermal type ejects an ink droplet by explosive growth of bubble in the chamber. Thermal inkjet printhead has several advantages compared with other technology such as low cost, high resolution, low noise, and ease of color printing. A core element of the inkjet printer is inkjet printhead, which is a successful product of micormachining technology. It determines the print quality, print speed, and maintenance. Conventional inkjet printhead fabricated by complex process including hybrid technology. The nozzle plate, manufactured separately, should be aligned and attached to the chip one by one with additional bonding process.

In this paper, we propose a new integrated fabrication method for the monolithic thermal inkjet printhead combining silicon micromachining and nozzle plate direct electroplating technologies. The heater elements are buried in a thin-sandwiched membrane and face down like a back shooter. However, to improve the efficiency of fluid supply, individual buried ink channel with non-symmetric throttle or neck is performed. Each ink channel corresponds to a single heat element to avoid any crosstalk issues. Ink slot is formed by Etching the substrate from the backside and channel is then connected with Ink slot. Electrical forming nozzle plate will be done later. In this structure, no more another ink channel material is necessary since it is formed on Si substrate.

2. DESIGN AND FABIRCATION

Figure 1 shows a perspective view of the monolithic inkjet head. The realization of buried ink channel array below silicon surface for printhead is achieved by anisotropic etching with KOH solution. Here, a poly silicon (1000Å) sacrificed layer will be deposited on the silicon and define the ink channel area. Considering the efficiency of fluid supply, individual buried ink channel with non-symmetric throttle or neck is designed as shown in Figure 2.

SiC(3500Å) is deposited and defined as a mask, KOH etching solution will etch the silicon to form the V-groove (20um) channel via Poly silicon sacrificed layer. After creating the ink channel, the open pore will be sealed by low stress PECVD dielectric film(12000Å)3. This process provides a planar surface for heat element to accommodate on. In addition to the

dimention of pores, the sealing material is also of critical importance. PECVD oxide, PECVD nitride or a combination of both can be used for sealing the structure. Stress and strain problems must be took attention here. Channel to channel space as small as 4um is possible because of the high lateral dimension control of anisotropic etching.

The next step is the creation of conductor and the heater. The heater is just on the diaphragm above the etched channel. After deposition and pattern the Al (6000Å) and TaAl(1000Å), low temperature PECVD dielectrics such as SiN/SiC (5000Å/3000Å)are deposited for passivation. A metal layer (2000Å) for the purpose of both passivation and electroplating seed layer is sputtered on the surface and then patterned using reactive ion etching. Another RIE etching will be applied to create open hole and bonding area for ink droplet and bonding respectively just after metal etching. Electroplating is used to form nozzle plate directly on chip4. On the back side of the wafer, the thermal oxide layer (16000Å) is patterned, and a second KOH etching is applied to etch the ink slot. The backside of the wafer should be aligned with the front side. A layer of wax protects front side from the corrosive chemical solution. This slot works as an ink supply chamber and connects to the front side pre-etched ink channel. Figure 3 shows the fabrication process for the monolithic inkjet head.

Prototype roof shooter with 300 dpi resolution and side shooter with 1000dpi have been designed. The realization of buried ink channel and surface planarization is shown in Figure 4. The open pore with 2×2um size is completely sealed. The minimum thickness to seal these pores is about 1.2um. Figure 5(a) and 5(b) show edge type and roof type shooter with heater on ink channel respectively. To edge shooter, wafer must be cut perpendicular to the channel orientation using a dicing machine to expose the nozzles. Figure 6 shows the relating location of electric wire and nozzle. The displacement of heater from nozzle is about 150um(not shown). Figure 7 shows a ink slot view of chip from back side. The front side ink channels connect to this backside ink reservoir. When a drop of ink is fired, the micro channel automatically refills from the reservoir by capillary action.

3. CONCLUSION

After the basic process were proven we construct the first sample. A monolithic printhead with high resolution potential has been developed. By direct forming nozzle plate on chip, alignment for bonding nozzle plate and chip could be avoided to cost down. In this structure, no more another ink channel material is necessary since it is formed on Si substrate. By direct forming nozzle plate on chip, alignment for bonding nozzle plate and chip could be avoided to cost down.

It is possible to fabricate both roof shooter and edge shoot by this technique. Right now, printhead with 50 nozzles and system pitch down to 25um (appropriate for 1000 dpi) is evaluating.

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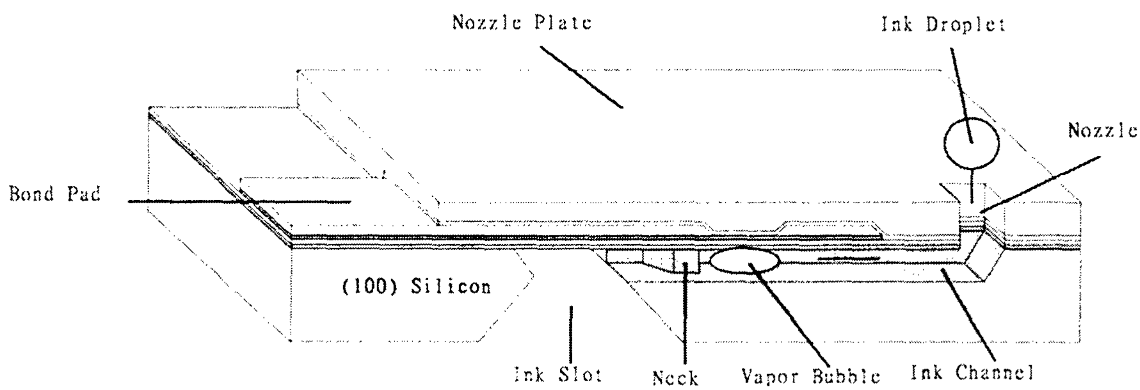


Figure 1. A perspective view of the monolithic inkjet head.

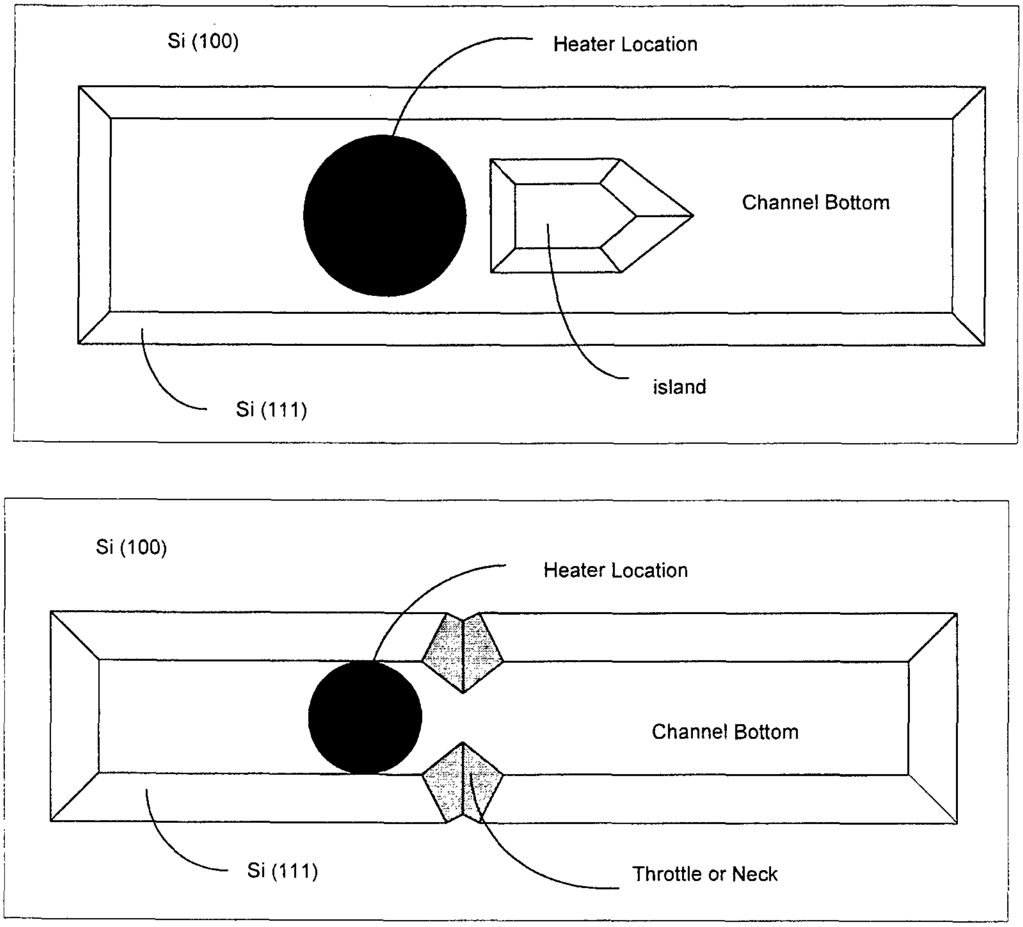


Figure 2. Design of neck or throttle for ink channel.

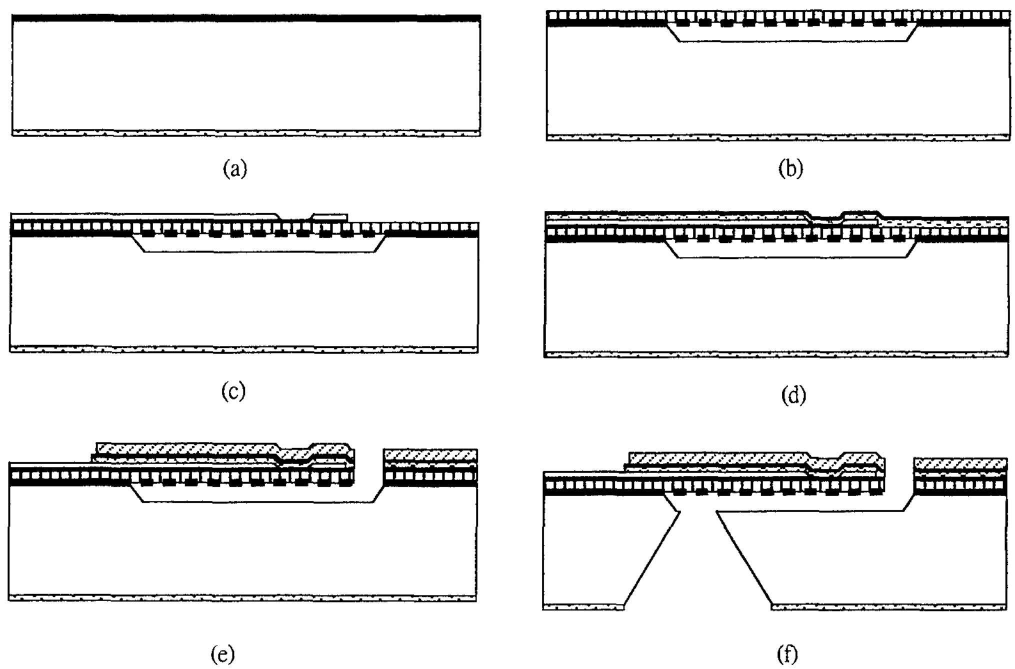


Figure 3. Process flow for the monolithic inkjet head. (a) Ink channel defined and protect by dielectric film. (b) Ink channel anisotropic etched and open pole sealed. (c) Conductor and heater creating. (d) Passivation deposition. (e) Pad area, nozzle hole define and nozzle plate electroplating. (f) Back side ink slot etching.

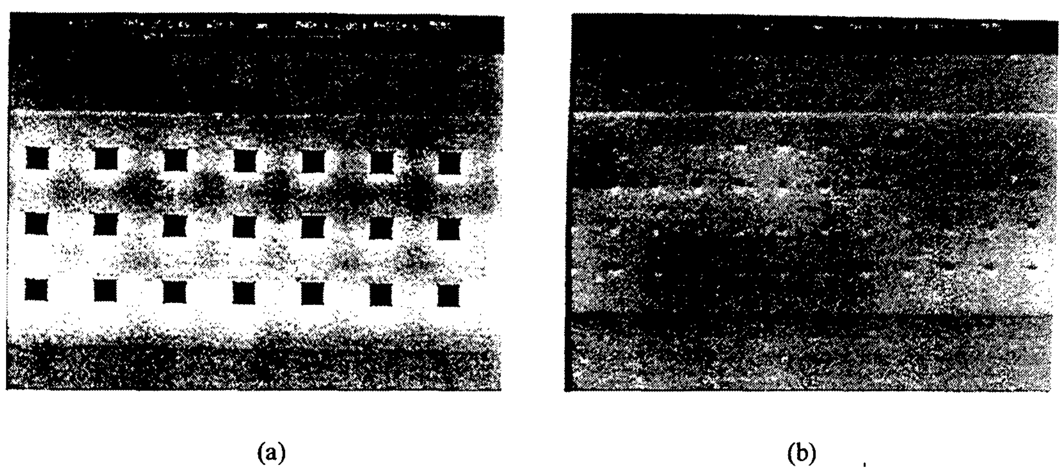
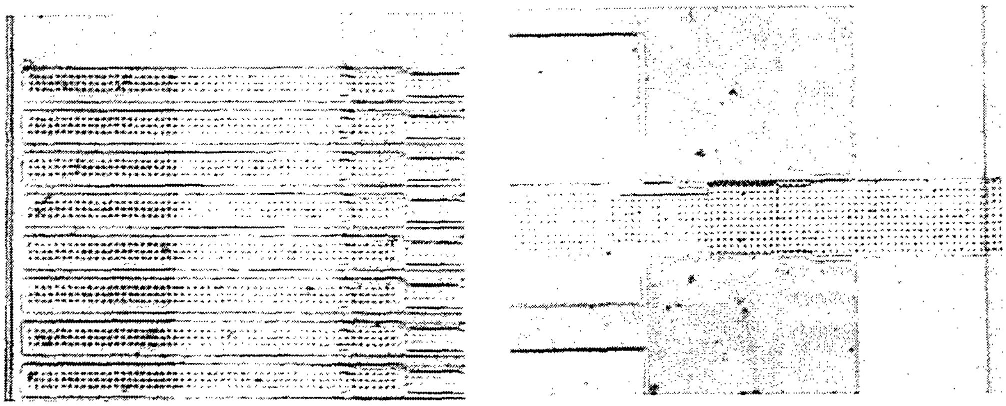


Figure 4. (a) 2um×2um open pores. (b) Pores is sealed by PECVD deposition.



(a) (b)

Figure 5. (a) 1000dpi edge side shooter. (b) 300 dpi roof shooter.

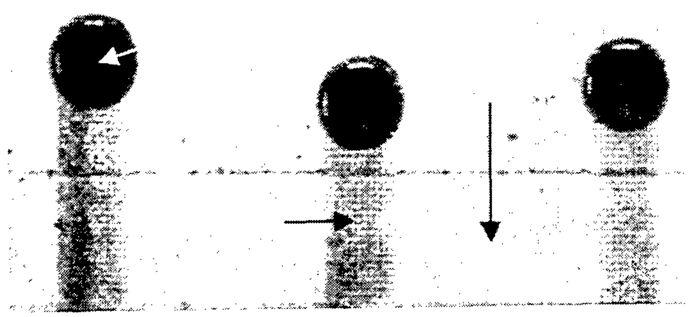


Figure 6. The relating location of nozzle and electric wire.

Figure 7. A ink slot view of chip from back side